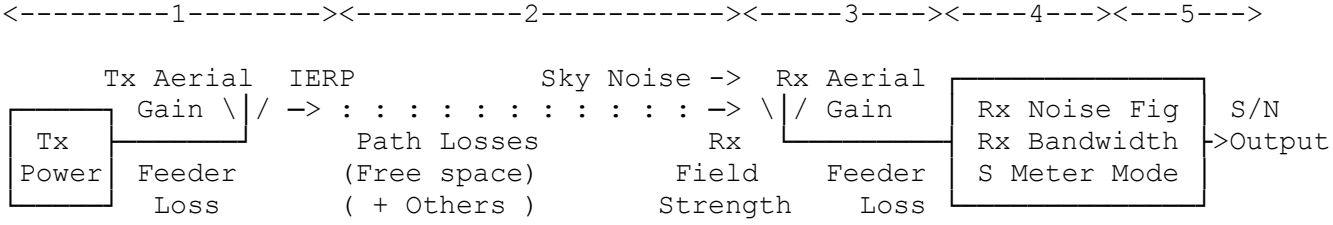
RF Signal Calculations

By G8MNY (Published BATC's CQTV 177, Updated Nov 21)
(8 Bit ASCII graphics use code page 437 or 850, Terminal Font)

With several radio path loss programmes now available to amateurs, it becomes possible to predict the P grade (or S meter for phone) for any contact not via the ionosphere.

Data is needed for these 5 parts of the problem.



1/ TX IERP	TX power. Coax & connector losses. Aerial gain dBi.
2/ PATH LOSS	NGRs for distance,) Aerial height,) used with a terrain database Frequency) for loss calculations.
3/ RX SIGNAL	Aerial gain dBi. Coax & connector losses. With 1/ & 2/
4/ RX SENSITIVITY	Sky Noise + Noise figure (preamp & Rx). Bandwidth.
5/ 'R' or 'P' GRADE	S/N Conversion for that mode.

Most people can only make a guess at these, or use makers figures where believed!

IN DETAIL..

TX ISOTROPIC EFFECTIVE RADIATED POWER.
This is a straight forward calculation best done in dBW.

TX IERP = TX dBW - ALL LOSS + AERIAL GAIN

PATH LOSS
This has 2 parts:- the Free space loss & other losses. The free space path loss can be calculated directly from the distance & frequency, where D is in km & F is in MHz.

FREE SPACE LOSS dB = 20LogD + 32.4 +20LogF

However, on VHF & UHF it is heavily modified by obstructions like hills, buildings, trees etc. The use of Path loss programme with a UK heights database can take into account hill diffraction loss, reflection loss etc, but this will still be only a best path guide. Under lift conditions losses can get close to the free space loss. If you don't have a programme you will have to guess at these additional losses. I use a programme called Tempath.

PATH LOSS = FREE SPACE + DIFFRACTION + REFLECTION + OTHERS.

RX SIGNAL
The level is now just the Rx losses added to the other figures & converted to dBm. (Decibel ref to 1mW)

SIGNAL (dBm) = TX IERP +30, -PATH LOSS + AERIAL GAIN - COAX LOSSES.

RX SENSITIVITY
This should include the sky noise term, but I have ignored this as @ VHF & UHF it is usually only a dB or so above the thermal noise, so it does not really alter a prediction by much.

The Rx sensitivity calculation is slightly more complex with bandwidth (in Hz) & overall noise figure (dB) needed to get the noise floor with the -174dBm/Hz from Boltzmann's constant (at room temp). The bandwidth figure assumes an ideal square I.F. response shape, so for example a Sat Rx with normal I.F. filtering will be 30MHz wide, a dedicated FM ATV RX good on sound & colour Rx may be 13MHz, & a narrow DX RX for B/W Dxing only may be 6MHz wide! On 70cms AM TV will be 5MHz unless a narrow I.F. is used. Wide FM is 200kHz I.F., NBFM 25kHz system uses 20kHz I.F., 12.5kHz system should be using a 7kHz IF, SSB uses 2.4kHz I.F., CW whatever I.F. you have 500Hz, & FT8 will be 6.25Hz.

Noise figures of preamps & Rx are additive, the preamp adds some noise to the signal but making the signal much bigger, but as long as the Rx noise is drowned by the amplified band noise + preamp noise by 10dB or so (not much more as you loose headroom performance), then take just the preamp noise figure as the system noise as this will then be quite accurate without calculating it. Noise figures of just the preamp active device itself can be very misleading as input socket, input tuned circuit & radiated/PCB losses can often add as much as 1-3 dB to this!

NOISE FLOOR (dBm) = NF -174 + 10Log Bandwidth (in Hz)

RX SIGNAL/NOISE RATIO
This is just the difference between the noise floor & the Rx signal. This is what is in the IF before the FM discriminator, AM or product detector.

S/N (dB) = SIGNAL - NOISE FLOOR

'P' GRADE CALCULATION
This is an arbitrary conversion, assuming for ATV P5 is 35dB S/N (e.g. good VHS tape) going down to P0 at no signal. With FM there is a capture affect & also the visible noise is quite different, but with narrow FM ATV (not a Sat Rx) the effect is not as far from linear as you might expect.
I have found this formula gives quite an acceptable conversion.

P Grade = (S/N +3) x 0.13

'S' METER CALCULATION
This is also a simple conversion, assuming 3dB/S point, that gives a fairly good 27dB S/N @ S9 on VHF & above, but with an added 1dB to get started makes 28dB S/N, which is a very good contact.

S Meter = (S/N -1) x 0.3

Note for HF 6dB/S point is normally used as these Rx are quite deaf & the band noise is usually 10-30dB above Rx thermal noise, & gives a greater meaningful range for the meter.

Fig.1 Example of a Path loss Programme (Tempath + Graphics to Print)

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                          Path loss : 134
                          ---------------
                    Free Space Loss:     129.3 dB
                    Diffraction Loss:      0.0 dB
                    Reflection Loss:       0.0 dB
                    Siting Loss:           0.0 dB
                    Round Hill Excess:     4.4 dB
                    At Frequency:        1248.0 MHz
                    Over a Distance of:   55.80 km

                         TQ335643 to SU850919
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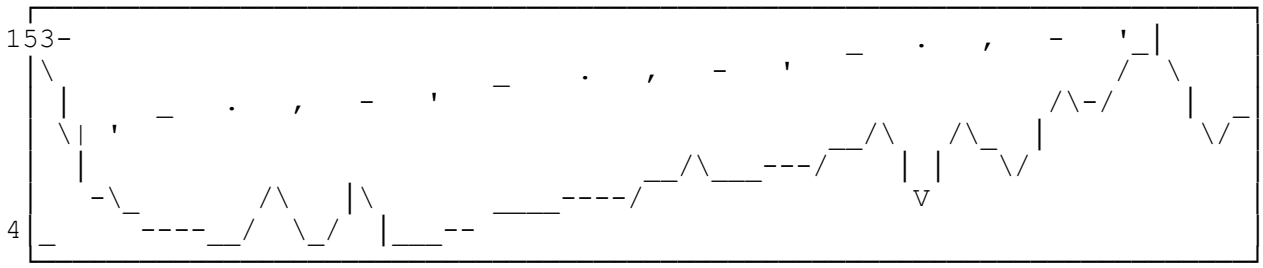

Fig 2 Example of my basic programme calculator.. (you want a copy I can send)

CALCULATED SIGNAL FROM G8MNY TO GB3HV

INPUTTED PARAMETERS:-

FREQUENCY 1248 MHz	POWER 20 W = 13 dBW
TX COAX -2 dB	TX AERIAL 17 dBi
RX COAX -1 dB	RX AERIAL 9 dBi
PATH LOSS -134 dB	NOISE FIGURE 1 dB
BANDWIDTH 13 MHz	

CALCULATED RESULTS:-

TX IERP = 632.4 Watts = 28 dBW

RX SIGNAL = -68 dBm = 89 uV (in 50 ohms)
RX NOISE FLOOR = -101.9 dBm
RF SIGNAL to NOISE = 33.9 dB

'S' METER = S 9 (in 13MHz)

'P' GRADE = P 4.7

Why don't U send an interesting bul?

73 de John G8MNY @ GB7CIP